ZAMM Zeitschrift fur Angewandte Mathematik und Mechanik 2018

# Mechanics of fiber composites: Forms of loss of stability and fracture of test specimens resulting from three-point bending tests

*Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia*

## Abstract

© 2018 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim On the basis of the linearized equations consistent theory of curvilinear bars the buckling problem of rectilinear short and long laminated fiber reinforced specimens under the three-point bending conditions has formulated. Based on the method of finite sums in the embodiment of integrating matrices numerical method for solving the above problem has developed. It was shown that the failure of the composite specimens under the three-point bending conditions is due to the implementation of non-classical shear buckling mode.

http://dx.doi.org/10.1002/zamm.201800063

## Keywords

adjusted equilibrium equation, fiber composite, geometrical and physical nonlinearity, integrating matrices, mechanical properties, numerical method, results of experimental studies, stability, test specimen, testing, three-point bending

## References

[1] X. Ming, D. F. Adams, A Plasticity Model for Unidirectional Composite Materials and its Applications in Modeling Composites Testing, 1995.
[2] H. Y. Lee, M. S. Seo, C. G. Kang, International Journal of Precision Engineering and Manufacturing-Green Technology 2016, 3, 259.
[3] M. C. Serna Moreno, A. R. Gutierrez, J. L. Martinez Vicente, Compos. Struct. 2016, 136, 706.
[4] C. E. Beldica, H. H. Hilton, Compos. Struct. 2001, 51, 195.
[5] N. Carbajal, F. Mujika, Polym. Test. 2009, 28, 150.
[6] N. Carbajal, F. Mujika, Polym. Test. 2009, 28, 618.
[7] N. Carbajal, F. Mujika, Polym. Test. 2011, 30, 578.
[8] W. C. Cui, M. R. Wisnom, Compos. Sci. Technol. 1992, 45, 323.
[9] H. Ullah, A. R. Harland, T. Lucas, D. Price, V. V. Silberschmidt, Comput. Mater. Sci. 2012, 52, 147.
[10] W. C. Cui, M. R. Wisnom, J. Strain Anal. 1992, 27, 235.
[11] W. C. Cui, M. R. Wisnom, M. Jones, Composite Engineering 1994, 4, 299.
[12] M. R. Wisnom, Compos. Struct. 1991, 18, 47.
[13] L. Dufort, S. Drapier, M. Grediac, Compos. Struct. 2001, 52, 233.
[14] M. Meng, H. R. Le, M. J. Rizvi, S. M. Grove, Compos. Struct. 2015, 119, 693.
[15] F. Mujika, I. Modragon, J. Compos. Mater. 2003, 34, 1041.
[16] F. Mujika, A. De Benito, I. Modragon, J. Compos. Mater. 2003, 37, 1192.

[17] G. Vargas, F. Mujika, Polym. Test. 2011, 30, 204.
[18] E. Sideridis, G. A. Papadopoulos, J. Appl. Polym. Sci. 2004, 93, 63.
[19] F. Mujika, N. Carbajal, A. Arrese, I. Modragon, Polym. Test. 2006, 25, 766.
[20] F. Mujika, Polym. Test. 2007, 26, 869.
[21] M. R. Wisnom, J. Compos. Mater. 1992, 26, 1173.
[22] M. R. Wisnom, Compsites 1994, 25, 394.
[23] W. Gong, J. Chen, E. A. Patterson, Compos. Struct. 2015, 123, 9.
[24] P. F. Liu, J. Yang, B. Wang, Z. F. Zhou, J. Y. Zheng, J Fail. Anal. and Preven 2015, 15, 101.
[25] F. Pashmforoush, M. Fotouhi, M. Ahmadi, J. Mater. Eng. Perform. 2012, 21.
[26] E. Hara, T. Yokozeki, H. Hatta, Y. Iwahori, T. Ogasawara, T. Ishikawa, Composites: Part A 2012, 43, 1828.
[27] T. Y. Kam, C. M. Chen, S. H. Yang, Compos. Struct. 2009, 88, 624.
[28] G. Caprino, P. Iaccarino, A. Lamboglia, Compos. Struct. 2009, 88, 360.
[29] A. K. Arnautov, Mech. Compos. Mater. 2005, 41, 467.
[30] V. N. Paimushin, V. I. Shalashilin, Dokl. Akad. Nauk 2004, 396, 492.
[31] V. N. Paimushin, V. I. Shalashilin, J. Appl. Math. Mech. 2005, 69, 773.
[32] V. N. Paimushin, V. I. Shalashilin, J. Appl. Math. Mech. 2006, 70, 91.
[33] V. N. Paimushin, Mech. Solids 2007, 42, 437.
[34] V. N. Paimushin, J. Appl. Math. Mech. 2007, 71, 772.
[35] V. N. Paimushin, N. V. Polyakova, J. Appl. Math. Mech. 2009, 73, 220.
[36] V. N. Paimushin, N. V. Polyakova, J. Appl. Math. Mech. 2011, 75, 691.
[37] R. A. Kayumov, S. A. Lukankin, V. N. Paimushin, S. A. Kholmogorov, Uchenye Zapiski Kazanskogo Universiteta. Seriya Fiziko-Matematicheskie Nauki 2015, 157, 112.
[38] D3518/3518M-94 (Reapproved 2001), Standard Test Method for In-Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a ±45◦ Laminate, vol. 15.03, Space Simulation; Aerospace and Aircraft; Composite Materials, ASTM International, West Conshohocken, PA 2005.
[39] N. A. Alfutov, P. A. Zinoviev, B. G. Popov, Computation of Multi-Layered Composite Plates and Shells, Machinostroyeniye, Moscow 1984.
[40] OST 1 90199-75, Composite Polymer Materials. Method for Determination of Shear Strength Using Bending Strength, 1985.
[41] RD 50-675-88, Calculations and Strength Tests in Engineering. Composite Materials Methods for Interlaminar Shear Tests, 1989.
[42] D790-03, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, vol. 08.01, Plastics, ASTM International, West Conshohocken, PA 2005.
[43] D2344/D2344M-00, Standart Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and their Laminates, vol. 15.03, Space Simulation; Aerospace and Aircraft; Composite Materials, ASTM International, West Conshohocken, PA 2005.
[44] GOST 32659-2014, Polymer Composites. Test Methods. Determination of Apparent Interlaminar Shear Strength by Short-Beam Method.
[45] I. B. Badriev, V. V. Banderov, M. V. Makarov, V. N. Paimushin, Applied Mathematical Sciences 2015, 9, 3887.
[46] R. Z. Dautov, V. N. Paimushin, Izv VuzovMatematika 1996, 10, 13 (in Russian).
[47] W. Grodzki, A. Lukaszewicz, Mater.wiss. Werkst.tech. 2015, 46, 269.